Operating Experience Weekly Summary 97-42

October 10 through October 16, 1997

Table of Contents

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EVENTS

1. DRUMS OF CONTAMINATED MATERIAL FALL FROM TRUCK

On October 7, 1997, at the Paducah Gaseous Diffusion Plant, 11 drums containing uranium tetrafluoride (UF4) rust fell from a truck during an on-site transfer. The truck was carrying twelve, 55-gallon drums, each inside an 85-gallon overpack. When the truck driver made a left turn, the drums shifted and fell against a holding strap on the side of the truck. The strap broke and the drums fell onto the roadway. Health physics personnel placed spill pads around the drums that were leaking condensation around the lids. They surveyed the roadway and identified five areas of contamination; four, approximately 4 square feet in size, and one area approximately 12 feet square. A survey of the material in the contaminated areas revealed levels ranging from 16,000 dpm/100 cm^2 to 100,000 dpm/100 cm^2 beta/gamma. Smears of the area, the overpacked drums, the truck, and a forklift used during the clean-up activity showed no removable contamination above limits. Unrestrained waste containers and drums can fall from trucks and forklifts resulting in a spill of contaminated or hazardous materials. (ORPS Report ORO--LMES-PGDPENVRES-1997-0011)

A similar event occurred at Paducah on October 3, 1997, when a 5-gallon drum containing hexane and acetone lab wastes fell off a forklift during transport. A waste operator had strapped the drum to the forklift mast as required by the drum-handling procedure, but during transport the pallet vibrated, and the drum fell between the forks to the roadway with the straps still attached. The operator noticed scratches on the drum and re-strapped it to the forklift to complete the transport. A foreman observed that the outer metal drum was damaged and the inner plastic drum was visible. The inner drum was not damaged and did not leak.

Health physics personnel cleared all of the overpacked drums for placement in storage, and Chemical Operations personnel decontaminated the spill areas. No one in the affected areas was contaminated. Waste operators will repackage the 5-gallon drum from the October 3 event. In both of these events, the truck and forklift were being operated on rough roads. Investigators continue to review these drum-handling occurrences to determine the causal factors and identify corrective actions.

OEAF engineers reviewed the following recent events that involved dropped containers and drums.

- On October 13, 1997, at the Hanford Remedial Action Projects, an empty roll-off box used to transport contaminated soil came loose from the haul truck, rolled backwards, and dropped onto the road while the truck was on an incline. A cable hook and safety latch released the box from the vehicle. Inspectors determined that the roller on the front of the box was of sufficient diameter to partially cover the safety latch, preventing full engagement. Inspectors have not determined why the cable hook released. (ORPS Report RL--BHI-REMACT-1997-0010)

- On September 23, 1997, at the Oak Ridge Y-12 Site, a 3,187-pound container of mixed waste slid off the forks of a forklift while an operator attempted to load it onto a flatbed truck on an incline. The container fell 3 feet to the pavement, spilling less than 1 gallon of the mixed waste. Radiological control technicians surveyed the spill and detected 12,000 dpm/100 cm^2 beta/gamma fixed plus removable contamination on the asphalt. (ORPS Report ORO--LMES-Y12WASTE-1997-0007)

- On August 27, 1997, at the Hanford Site, a 55-gallon drum of low-level waste fell off a pallet and landed on the ground. The 496-pound drum was not breached and did not spread any contamination. A teamster was using a fork truck to remove the pallet of two drums from an enclosed van when the rope for the roll-up door for the van caught on the locking ring bolt of the drum and pulled it from the pallet. (ORPS Report RL--PHMC-SOLIDWASTE-1997-0012)

OEAF engineers searched the ORPS database for dropped drums and containers across the DOE complex and found 42 occurrences. Figure 1-1 shows that facility managers reported personnel error as the root cause for 48 percent of the occurrences. They also reported that management problems accounted for 25 percent of the occurrences. Further review shows that 58 percent of the personnel errors were reported as inattention to detail, and 30 percent of the management problems were reported as policy not adequately defined, disseminated, or enforced.

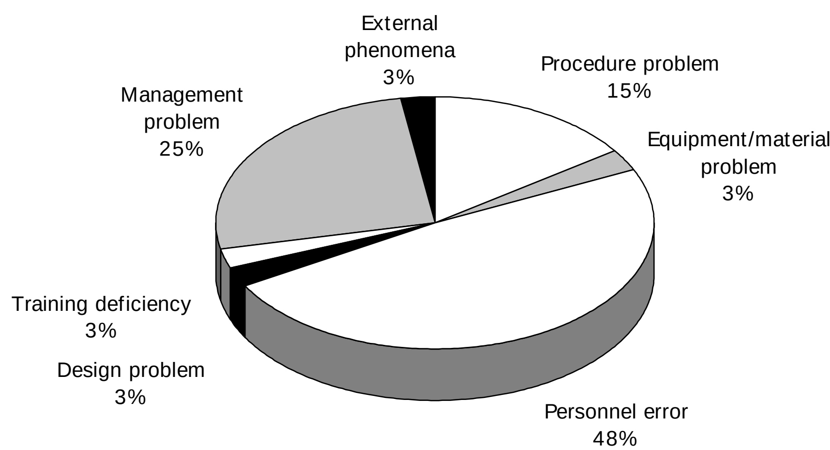


Figure 1-1. Distribution of Root Causes for Dropped Drums and Containers[1]

These events underscore the importance of waste handlers ensuring that drums and containers are properly secured when transporting them. A dropped container could be breached, resulting in a spill of hazardous materials. Spilled materials can cause environmental damage, contamination of equipment, and contamination or injury to personnel. Clean-up of preventable spills not only results in additional costs, but usually generates more waste material. Truck drivers have full responsibility for the safe operation of the vehicle and for securing the load. They should be careful to avoid sudden changes in direction or emergency stops. Acceleration, deceleration, and turns can put high dynamic forces on the load and securing devices. Forklift operators should carry loads slightly tilted back and as low to the ground as reasonable. If the load blocks forward vision, operators should drive in reverse, unless a flagman is available. It may also be necessary to back down inclines when carrying a load. Restraining devices and tie-downs should be checked to ensure they are in good working order, and drivers should choose routes that take advantage of better roads. Securing drums or containers during handling may not always be practical, such as during loading or unloading. Waste handlers should exercise extra care when

[1] OEAF engineers searched the ORPS database using the All Narrative “forklift OR truck AND drop@ OR fall OR fell AND drum@ OR container@ for the period 1990 to present. The search produced 80 occurrence reports. A 100 percent review of these reports identified 42 related occurrences.

handling unrestrained loads. DOE O 1540.1A, *Materials Transportation and Traffic Management*, provides loading methods and tie-down requirements in chapter II.

KEYWORDS: drum, mixed waste, spill, waste handling, forklift, dropped load

FUNCTIONAL AREAS: Materials Handling/Storage

2. STOP WORK ORDER ISSUED FOR REPEATED FALL PROTECTION VIOLATIONS

On October 7, 1997, at the Los Alamos National Laboratory, a safety inspector initiated a stop work order to a roofing subcontractor because of repeated fall protection violations. On September 30, October 1, and October 7, the safety inspector observed a subcontractor safety monitor assisting in roofing activities. OSHA regulations and contractor procedures required using a dedicated safety monitor who had no other responsibilities. The safety inspector notified the contract organization responsible for the subcontractors about each of the occurrences. The contract organization quality assurance representative counseled and disciplined the roofers for each violation, including removing the subcontractor superintendent from the site and requesting a more safety-conscience crew when the third violation occurred. OSHA reports that each year, on average, between 150 and 200 workers are killed and more than 100,000 are injured, as a result of falls at construction sites. (ORPS Report ALO-LA-LANL-LANL-1997-0002)

The roofers reviewed and signed the contractor's safety monitoring system procedure before starting the roofing activities. The procedure included a list of requirements for mitigating falling hazards, tripping hazards, and emergency situations. On September 30, the safety inspector observed the roofers performing roofing activities without a dedicated safety monitor. The assigned monitor assisted in performing roofing activities when he should have been observing them. The safety inspector notified the contractor's quality assurance representative, who addressed the concern with the roofers and the monitor. On October 1, the safety inspector again observed the assigned safety monitor performing roofing activities and notified the quality assurance representative. The quality assurance representative allowed the employees to complete their task, then sent them home for the day. The following day the quality assurance representative reviewed the safety monitoring system procedure with the roofers before allowing them to continue work. On October 7, the safety inspector observed the designated safety monitor sweeping with a push broom, not paying attention, while one roofer was on the edge of the roof using a hand-saw. The safety inspector immediately initiated a formal stop work order.

The facility manager designee held a critique of the events. Corrective actions included requiring the contractor organization to provide a dedicated safety monitor to observe the subcontractor roofing activities for the remainder of the project.

This is the second subcontractor stand-down this year at Los Alamos involving inadequate fall protection. Weekly Summary 97-16 reported that procurement managers at Los Alamos National Laboratory initiated a stand-down of a construction subcontractor on April 2, 1997. The stand-down resulted from numerous safety deficiencies identified in a subcontractor employee's formal complaint to the DOE/Albuquerque Operations Office. In response to the formal complaint, DOE/Albuquerque Operations personnel performed an assessment of the alleged unsafe work environment. The following are examples of the deficiencies identified during the assessment.

- inadequate fall protection guard rails

- inadequate training in the use of ladders, scaffolding, excavation, personal protective equipment, fall protection, and hazardous materials

- trip and impalement hazards from bottles, wire, exposed nails, and insulating tarps scattered throughout the area

A senior construction manager for the subcontractor submitted a written response concerning the previously identified deficiencies stating that all physical deficiencies had been corrected. The subcontractor's corrective action plan included (1) providing a dedicated safety manager on site, (2) conducting daily safety briefings before starting work, (3) providing trending and tracking data, (4) assigning craftsmen to inspect and repair safety controls, (5) posting names and phone numbers for reporting safety/quality deficiencies, and (6) improving the worker training program. Based on a review of the corrected deficiencies and the corrective action plan, procurement managers lifted the stand-down. However, they stated that if safety problems continued to exist they would suspend work.

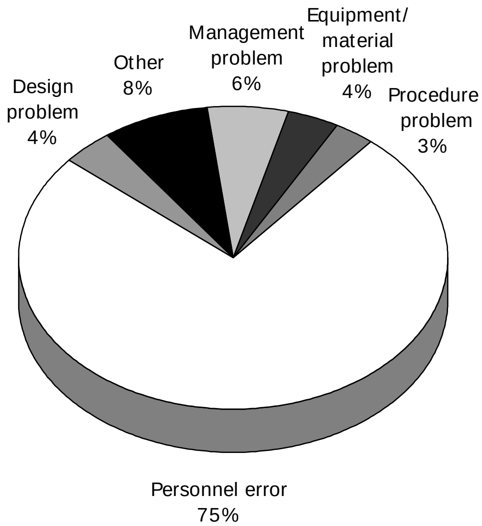
NFS has reported on fall protection violations in several Weekly Summaries. Following are examples of some of the events reported.

- Weekly Summary 96-49 reported that two electricians at Argonne National Laboratory—West repaired a rain gutter heater without using required fall protection. The electricians were working near the edge of a roof, installing heater cables in the rain gutter and downspouts. Investigators determined that the electricians were instructed by their supervisor to wear fall protection at the pre-job briefing. (ORPS Report CH-AA-ANLW-HFEF-1996-0008)

- Weekly Summary 96-38 reported that two carpenters at the Rocky Flats Environmental Technology Site were installing a lean-to roof and had climbed onto the roof from a scaffold without using fall protection. They had adequate fall protection on the scaffold but did not wear harnesses when they stepped onto the roof. The carpenters did not have harnesses because the work planners did not expect them to leave the scaffold to complete the work. The work order provided for fall protection on the scaffold but did not address fall protection on the roof. (ORPS Report RFO--KHLL-771OPS-1996-0151)

- Weekly Summary 96-27 reported a fall fatality at Idaho National Engineering Laboratory. A subcontractor project engineer fell approximately 17 feet from a temporary platform. The engineer, who was not wearing fall protection, suffered severe head and neck injuries and died. Workers built the temporary work platform to catch falling tools and parts and to support a transition piece previously installed as part of a ventilation system. The platform had no guardrails, toeboards, or other fall protection. While escorting a vendor who was inspecting a crane, the engineer stepped from the waste stack onto the temporary platform and fell. The Office of Environment, Safety and Health issued a Type A Accident Investigation Board Report that stated that hazards were not identified and there were no barriers in place to prevent the accident. (INEL Lessons Learned #96116, OEWS 96-08, Type A Accident Investigation Board Report on the February 20, 1996, Fall Fatality at the Radioactive Waste Management Complex Transuranic Storage Area - Retrieval Enclosure, ORPS Report ID--LITC-RWMC-1996-0001)

OEAF engineers searched the ORPS database for reports involving fall protection and found 135 occurrences. Figure 2-1 shows the distribution of direct causes reported by facility managers for these events. Personnel error represented 75 percent of the direct causes. Procedure not used or used incorrectly accounted for 63 percent of the personnel errors.



Personnel Error	Percent
Procedure not used or used incorrectly	63
Inattention to detail	18
Other human error	17
Communication problem	2

Figure 2-1. Distribution of Direct Causes for Fall Protection Events[1]

This event illustrates the need for managers to closely supervise subcontractors that perform construction work at DOE facilities. Managers should provide safety oversight of subcontractor administrative controls, safety programs, and work plans to ensure subcontractor personnel perform work safely and in safe working environments. Managers should review the following Order, standard, and OSHA regulations to ensure all aspects of safety are addressed in procedures and that available operating experience information is incorporated into safety programs. In 1994, the Bureau of Labor Statistics reported 32 construction fatalities because of falls. Falls represented 10 percent of all fatalities in 1994.

- DOE O 4330.4B, *Maintenance Management Program*, chapter II, section 8.3.6, "Control of Non-Facility Contractor and Subcontractor Personnel," states that non-facility contractor and subcontractor managers should be held accountable for the work performed by their personnel.
- DOE-STD-1010-92, *Guide to Good Practices for Incorporating Operating Experiences*, states that using previous experience should provide a positive method for facilities to improve their operations, thereby making them safe for employees, the public, and the environment.
- OSHA Regulation, 29 CFR 1926, subpart M, section 501, *Duty to Have Fall Protection*, requires that employees engaged in roofing activities be protected from falling by (1) guardrail systems, (2) safety net systems, (3) personal fall arrest systems, and (4) a combination of a warning line system and guardrail system or a warning line system and a safety monitoring system. Employees working on roofs

[1] OEAF engineers searched the ORPS database using the graphical users interface for reports with all narrative "fall protection" and found 135 reports. Based on a random sampling of 20 events, OEAF engineers determined that each slice is accurate within ± 1.17 percent.

50 feet or less in width are required to use a safety monitoring system (i.e., without the warning line system).

- OSHA Regulation 29 CFR 1926, subpart M, section 502, *Fall Protection Systems Criteria and Practices*, requires employers to designate a competent person to monitor the safety of other employees. The safety monitor must be able to (1) recognize fall hazards, (2) warn employees who are unaware of the fall hazards or are acting in an unsafe manner, (3) be on the same walking/working surface and within visual sighting distance of the employee being monitored, (4) be close enough to communicate orally with the employees, and (5) not have other responsibilities that could take attention from the monitoring function.

OSHA regulations can be found at URL http://www.osha-slc.gov/.

KEYWORDS: construction, fall protection, stop work

FUNCTIONAL AREAS: Construction, Industrial Safety

3. FREEZE PROTECTION REMINDER AND SEVERE WEATHER PLANNING

This week OEAF engineers reviewed several freeze protection events and related documents about the potential consequences of severe cold weather on equipment, systems, and operations. With the onset of the cold weather season, personnel at DOE facilities are reminded to review their freeze protection plans and implement improvements as necessary. Facilities without such plans should begin developing them immediately. This year facility personnel should also prepare for the potential impacts of El Niño, a weather-disrupting phenomenon caused by a warm-water mass in the Pacific Ocean. Last winter 25 freeze protection events were reported to ORPS. Severe damage can result from frozen water lines, valves frozen in position, frozen tank contents, or ice accumulation on equipment. Cold weather damage can be costly to clean up or repair and can affect facility operations. Comprehensive freeze protection programs help minimize or avoid events related to cold weather.

NFS has reported on several freeze protection events in the Weekly Summary. Following are examples of some occurrences reported during the winter of 1996/1997.

- Weekly Summary 97-05 reported on three freeze protection events. At the Savannah River Site, a frozen impulse line for a steam reducing station prevented steam flow to a stack jet, resulting in actuation of an off-gas, low-flow interlock for a dissolver. Investigators determined that a tarpaulin covering the reducing station to provide freeze protection had been removed. At Rocky Flats Environmental Technology Site, fire fighters responded to a fire suppression system flow alarm and found water leaking from fire system piping and from domestic water lines. Investigators determined that the pipes froze as a result of sub-zero ambient temperatures. At Oak Ridge Y-12 Site, water froze and damaged a fire protection sprinkler system in a building containing a paint shop. Fire protection personnel assessed the damage and found that ten cast-iron pipe fittings (elbows and tees) had cracked. Investigators found an outside door adjacent to the damaged area unlocked and standing open. (ORPS Reports SR--WSRC-FCAN-1997-0001, ORO--LMES-Y12SITE-1997-0002, and RFO--KHLL-NONPUOPS2-1997-0001)

- Hanford facility managers reported to ORPS that a sanitary water line froze, rupturing an eyewash station and spilling approximately 80,000 gallons of water. No freeze protection was provided. (ORPS Report RL--PHMC-TANKFARM-1997-0002)

- Pantex facility managers reported to ORPS that a mixture of snow and rain accumulated in a containment pan surrounding sections of a diesel generator fuel supply and the return lines froze, causing the fuel in the lines to jell. (ORPS Report ALO--AO-MHSM-PANTEX-1997-0003)

- Weekly Summary 96-52 reported that firemen at the Rocky Flats Environmental Technology Site responded to a fire suppression flow alarm and discovered a heavy flow of water on the second floor of a building leaking into a plutonium storage vault on the first floor. Investigators determined that the tee failed because of inadequate freeze protection procedures. (ORPS Report RFO--KHLL-SOLIDWST-1996-0166)

- Weekly Summary 96-02 reported that managers at the Rocky Flats Waste Storage Facility reported that 11 waste storage tents sustained considerable damage because of gale-force winds. Snow later entered some of the damaged tents and represented an additional problem when it melted. (ORPS Report RFO--KHLL-WSTREPACK-1996-0001)

Burst pipes, frozen water lines, and cracked sprinkler heads in fire protection systems are frequently reported problems during cold weather. Other frequently reported problems include roofs collapsing from the weight of snow and ice, flooding when snow melts, and electrical malfunctions from water leaking into buildings. In addition to cold weather protection, seasonal facility preservation plans to ensure continued safe facility operations should be established for (1) flash floods, (2) hurricane watches and warnings, (3) tornado watches and warnings, and (4) extreme hot/dry weather. Plant status at the time of a severe weather condition should dictate actions required to place the plant in a state of readiness for seasonal facility preservation. Facility managers should consider seasonal- related problems a priority and take immediate actions to minimize damage.

Facilities managers should determine how long buildings can be without power. They should also develop specific contingency plans for connecting temporary power sources, including (1) what size generator is required; (2) where and how to connect power; (3) where to locate and ground a generator; and (4) how to introduce and route generator power cables into buildings. These contingency plans should be detailed and readily available to the personnel installing temporary power; otherwise, workers could introduce additional hazards into the work environment.

Several steps can be taken to establish freeze protection for facility systems and equipment. These steps, together with contingency plans for severe weather, should be incorporated into written procedures and periodically reviewed for adequacy. The following list (from DOE O 4330) identifies some typical measures that should be included in freeze protection plans.

- Clean, service, and functionally test heating systems, and ensure that power and temperature controls are protected against inadvertent deactivation by unauthorized personnel.

- Check antifreeze used in cooling systems, and replace it as necessary.

- Secure all air intakes, windows, doors, and other access areas that could provide abnormal in-flows of cold air.

- Develop plans for alerting personnel and providing increased surveillance in periods of extreme, unusual, or extended cold. Operations or maintenance personnel should be on call to respond to these events.

- Install temperature alarms or automatic back-up heat sources on systems that require special protection because of hazards or costs associated with freeze damage.

- Inspect outside storage pads and unheated storage areas to ensure that no materials are susceptible to freeze damage.

- Ensure cold weather gear is readily available for emergency and operations personnel.

- Review wet-pipe sprinkler systems for areas susceptible to freezing, and develop provisions for actions such as activating auxiliary heat, draining, and posting fire watches.

A task team should be established to provide for the development and implementation of objectives for severe weather protection plans. Plans should ensure that preparatory actions and requirements imposed to provide seasonal weather protection, particularly those taken to restrict safety system functions, are reviewed by facility operations and safety personnel before implementing. The following list identifies some typical measures included in cold weather protection plans.

- Inspect for heat-tape degradation.

- Inspect dry-pipe fire protection systems to verify that all water is drained.

- Review outstanding work packages to ensure that freeze protection equipment is returned to service as soon as possible.

- Review procedures to ensure availability of compensatory measures in the event of power loss to heat tracing or other freeze protection equipment.

- Review administrative controls governing temporary equipment to ensure availability of freeze protection when needed.

- Review administrative controls governing design changes to ensure that freeze protection considerations are addressed (e.g., adding drains when changing a wet-pipe fire protection system to dry-pipe).

- Review configuration of shut-down facilities to determine if freeze protection is required.

- Develop a program to look at long-range weather projections and determine necessary actions to prevent systems from freezing in these facilities where cold weather is typically not expected.

OEAF engineers searched the entire ORPS database and found 453 freeze protection events. Figure 3-1 shows the root causes for these events. A review of these events shows that 33 percent of these events were attributed to management problems, with an additional 24 percent attributed to design problems. Further analysis revealed that 32 percent of management problems were attributed to work organization/planning deficiencies; an additional 31 percent were attributed to inadequate administrative control. This indicates that if facility managers convey the importance of thorough freeze protection plans to employees responsible for developing them, many events could be avoided. Figure 3-2 shows the distribution by nature of occurrence for these events. A review by nature of occurrence shows that 59 percent of freeze protection events affected the facility condition. Further analysis revealed that 44 percent of events affecting facility condition were attributed to vital system/component degradation; an additional 34 percent affected operations. Site reviewers should use lessons learned from these occurrences when conducting assessments of current freeze protection programs, equipment, and systems.

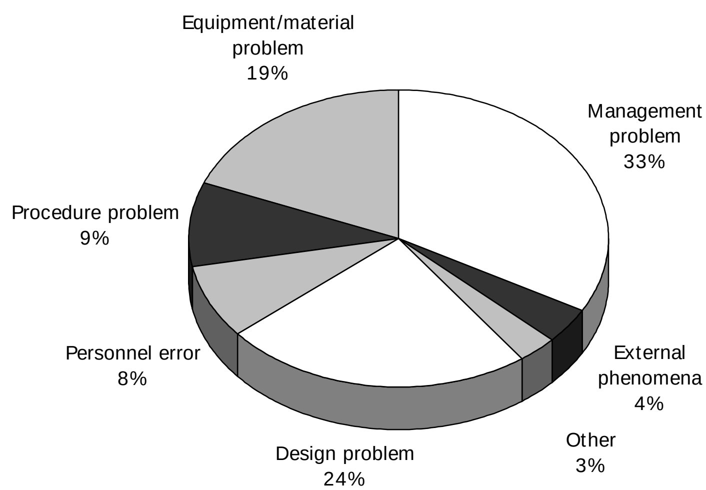


Figure 3-1. Distribution of Root Causes for Freeze Protection Events[1]

[1] OEAF engineers searched the entire ORPS database using the graphical users interface for all narrative “freeze AND protection” and found 453 events that identified 501 nature of occurrences. Based on a random sampling of 25 events, OEAF engineers determined that each slice is accurate within ± 2 percent.

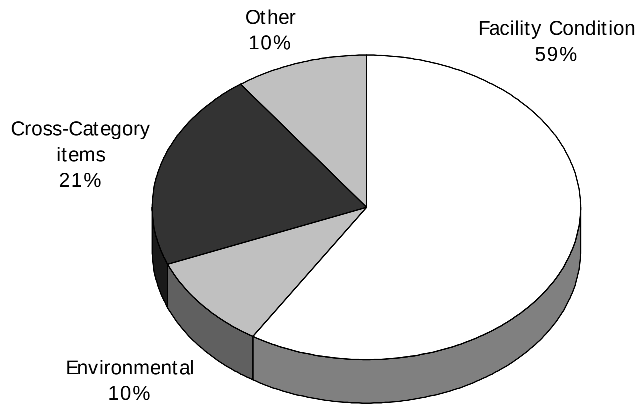


Figure 3-2. Distribution of Nature of Occurrences for Freeze Protection Events[1]

Facility managers should review their systems and equipment maintenance histories, policies, procedures, and work-planning processes and should walk-down systems to identify potential cold weather problems. Facility managers should also identify corrective actions and implement them before problems occur.

This winter facility managers should also consider weather abnormalities that may occur because of El Niño. The impacts of El Niño on climate show up most clearly during winter. Reports on how El Niño will affect weather patterns across the country are varied. According to some reports, it is expected that some locations could receive substantially more precipitation than in previous years. The precipitation could be in the form of snow, rain, or a mixture of both, depending upon geographical location. Facility managers should review their severe weather plans to ensure dikes can handle additional amounts of water, roofs can withstand additional loads, and water leakage into facilities is minimized. Additional information on El Niño and its effects can be found on the Internet at http://www.pmel.noaa.gov/toga_tao/el-nino/home.html. Information for mitigating El Niño consequences can be found on the Internet at http://www.fema.gov/nwz97/elnino.htm. Since long-range weather forecasting has improved, OEAF recommends that facilities implement weather and storm warning monitoring systems to ensure sufficient time exists to implement severe weather plans.

- DOE O 4330.4B, *Maintenance Management Program*, chapter II, section 19, "Seasonal Facility Preservation Requirements," requires a program to prevent equipment and building damage due to cold weather. The Order states that the program should include a freeze protection plan, including details on inspections, preventive maintenance, and corrective maintenance to ensure continued safe facility operations. Section 16, requires a maintenance history and trending program. Maintenance planners, coordinators, supervisors, and craft personnel should use maintenance history on a routine basis to identify previous maintenance work and its results.

- DOE-STD-1064-94, *Guideline to Good Practices for Seasonal Facility Preservation at DOE Nuclear Facilities*, provides guidance to assist facility maintenance organizations in the review of existing methods (and the development of new methods) for establishing a seasonal maintenance program. Section 3.4.1 of the guide includes cold weather preparation information; Appendix A provides an example of a cold weather checklist. This standard also contains guidance for hurricanes, tornadoes, cold weather, flash floods, and other natural disasters.

- DOE-STD-1021-93, *Natural Phenomena Hazards Performance Characterization Guidelines for Structures, Systems, and Components,* provides guidance on assessing system operations to identify hazards to personnel and equipment and on developing hazard prevention or mitigation measures.

- DOE-STD-1010-92, *Guide to Good Practices for Incorporating Operating Experiences*, states: "The use of experience gained should provide a positive method that a facility can use to improve their operations, making them efficient, cost-effective, and safe to the employees, the public, and the environment." Managers, supervisors, and operators should review operating experience information and implement it as the standard suggests. Lessons learned are valuable only if the information they communicate is used.

- DOE/EH-0213 "Cold Weather Protection," October 1991, Office of Environment, Safety and Health, Bulletin 91-4, provides insight, corrective actions, and recommendations applicable to sites susceptible to cold weather. This bulletin can be found at URL http://tis.eh.doe.gov:/80/docs/bull/links.html.

KEYWORDS: freeze protection, maintenance

FUNCTIONAL AREAS: Operating Experience, Lessons Learned

FINAL REPORT

1. WATER HAMMER PROBLEMS AT ROCKY FLATS

This week OEAF engineers reviewed a final occurrence report on water hammer problems at the Rocky Flats Environmental Technology Site. On May 7, 1997, technical support and utilities personnel notified a building manager that water hammers were continuing to occur in the steam system at two locations within the facility, as well as outside. The building manager cordoned off the affected areas and restricted access until a fact-finding team identified the cause of the water hammers and developed corrective actions. Water hammer events are significant because they can cause fatalities, personnel injury, and equipment damage. (ORPS Report RFO--KHLL-SOLIDWST-1997-0014)

The building manager conducted a fact-finding meeting and formed a team to coordinate efforts between the integrating contractor and the subcontractors involved in the operation of the site steam system. They determined that water hammers primarily occurred in one building, but were impacting six others. They also determined the direct and root cause of these events was an equipment/material problem (defective or failed part) because valves and steam traps were not operating as designed. Steam traps drain and remove condensate automatically from the steam lines, and the valves regulate the flow of steam within the system. As the steam gives up heat, it converts to condensate. The traps were not removing condensate from the lines and were allowing backflow of steam and condensate.

Engineers determined that six traps in a valve station were not functioning properly. They also determined that condensate accumulated in the steam lines during off-peak hours. When steam demand increased, the condensate mixed with the steam, causing a "flash" condensate-induced water hammer. Steam and water cannot mix safely in a piping system without risking condensate-induced water hammer. The engineers reviewed the steam trap design and decided to replace the existing "bucket" style steam traps with newer, more effective "orifice" traps. The new style trap is designed to drain condensate continuously and completely. These traps have no internal moving parts, which will greatly reduce trap maintenance. The new traps were installed with a special 40-mesh stainless steel strainer insert to trap any particles or contaminants before they reach the drain nozzle.

The condensate that drains from piping system traps collects in a condensate tank. The temperature of the tank was 200 degrees Fahrenheit. Engineers believe this temperature contributed to the hammer problems while the piping systems heated up. As a corrective action, mechanics repaired condensate line leaks, repacked a condensate pump, and removed the insulation around the condensate tank. Condensate tank temperature dropped to 180 degrees Fahrenheit, which was within the parameters for efficient warming of the pipes with no discernable hammer. Between June 17 and 19, 1997, utilities operators successfully reintroduced steam to the system for all affected buildings with no discernable "hammer." Before reintroduction of steam, operators emptied condensate from the steam and condensate lines, then manipulated valves to slowly introduce steam and isolate any potential hammering.

This event illustrates that facility personnel were aware of, and sensitive to, water hammer issues. Facility management took appropriate steps to isolate the steam system to prevent injury to personnel and equipment damage. Engineering personnel determined that the water hammers were caused by several valves and traps that were not operating as designed and by a condensate collection tank with system leaks and inefficient valves. Engineers corrected the steam system deficiencies and design problems by replacing older-design steam traps with newer, more effective equipment.

NFS has reported other water hammer events in the Weekly Summary. The following are examples.

- Weekly Summary 96-40 reported that seven workers at a commercial nuclear power plant were injured when an 18-inch diameter reheater drain line ruptured because of a water hammer. All seven workers suffered serious steam burns and steam inhallation injuries. (NRC Event No. 31053)

- Weekly Summary 96-39 reported that two power operators caused a condensate-induced water hammer event at the Hanford Plutonium Finishing Plant when they opened a bypass valve instead of a diaphragm-operated valve as directed in a work package. Investigators determined that the potential for water hammer was not discussed during the pre-job briefing. (ORPS Report RL--WHC-PFP-1996-0038)

Serious water hammer events at DOE facilities have resulted in Type A accident investigations. On June 7, 1993, a water hammer event at Hanford resulted in a valve rupture and fatal injury (ORPS Reports RL--WHC-WHC300EM-1993-0022). The *Type A Accident Investigation Board Report, June 7, 1993, U-3 Pit Valve Failure Resulting in a Fatality at the Department of Energy Hanford Site*, identified probable causes of the event to be inadequacies in operating practices, lessons learned, training, operating procedures, policy, guidance, safety implementation, design, and oversight. On October 10, 1986, a condensate-induced water hammer at the Broohaven National Laboratory resulted in two fatalities and two severe injuries. The Type A Accident Investigation Board determined the direct cause was the use of an in-line gate valve to remove condensate instead of drains that had been installed for that purpose. There were no written instructions for warming and activating the steam lines, and there was no formal training program to familiarize steamfitters with specific systems at Brookhaven. (Type A Investigation Report, November 14,1986)

Water hammers can cause serious piping and equipment damage. They can also cause uncontrolled releases of radioactive or hazardous materials and serious injury or death. These events can be prevented with planning, procedures, equipment design and condition, and cognizance of steam and water conditions. Appropriate training and procedures provide a measure of protection against water hammers. Managers at DOE facilities should review their procedures and training to determine if their controls will prevent water-hammer damage.

In June 1995, the Office of Environment, Safety and Health issued Safety & Health Bulletin 95-01, "Averting Water Hammers and Other Steam/Condensate System Incidents." This bulletin provides lessons-learned information and recommendations from DOE-sponsored workshops on water hammers and water hammer prevention. To obtain copies of this publication, call (301) 903-2641. The April 1994 article, *Steam Line Water Hammer: Cause and Prevention*, published in the *Occupational Safety Observer*, discusses (1) causes of water hammer, (2) methods to control condensate accumulation, (3) heat-up practices, and (4) proper system design. Mark Gintner of the Westinghouse Hanford Company has video training tapes on condensate-induced water hammer. Information on how to obtain these tapes and other training materials on condensate-induced water hammer may be obtained by contacting him at (509)-373-9145, or electronically, mark_a_gintner@rl.gov.

KEYWORDS: water hammer, condensate, steam trap

FUNCTIONAL AREAS: Operations, Startup, Design

OEAF FOLLOWUP ACTIVITY

1. CORRECTION TO WEEKLY SUMMARY 97-39, ARTICLE 2

The second paragraph of Article 2 in Weekly Summary 97-39 incorrectly stated that radiological levels had increased to 30 mrem/hr on contact with the manipulator. The article should have stated that the radiological levels had increased to 30 rem/hr on contact with the manipulator.

KEYWORDS: radiation, internal exposure, contamination

FUNCTIONAL AREAS: Radiological Protection, Maintenance